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(12) UK Patent Application (19) GB (11) 2 135 842 A

(43) Application published 5 Sep 1984

(21) Application No 8301792

(22) Date of filing 22 Jan 1983

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(51) INT CL^3
H04Q 11/04

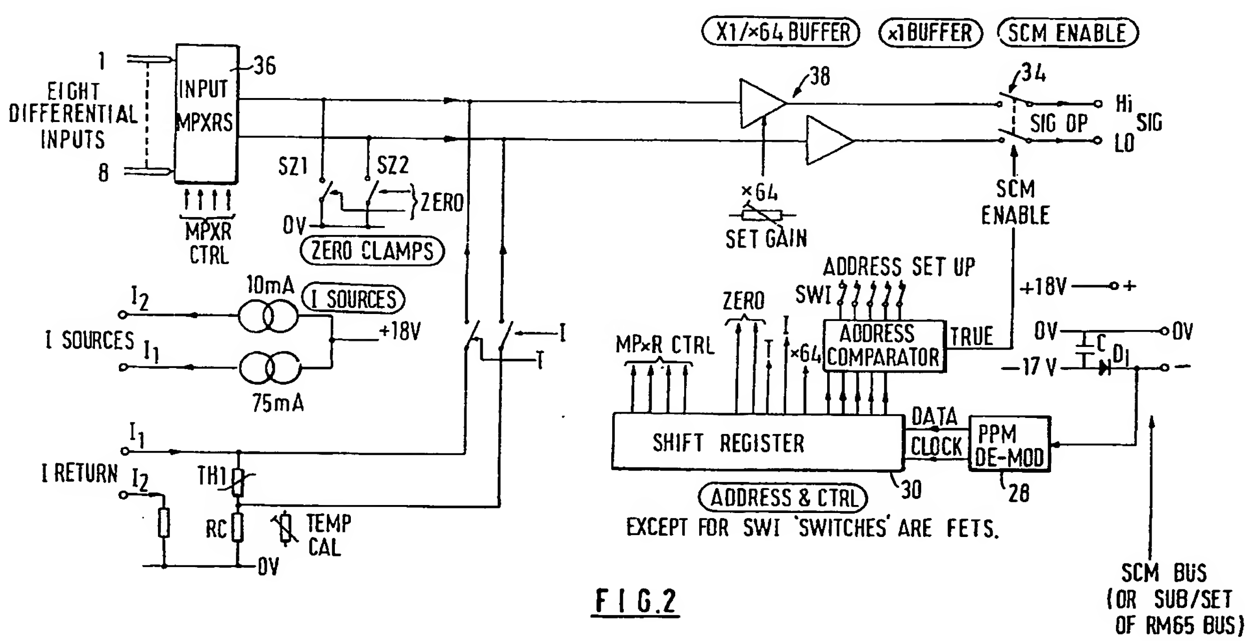
(52) Domestic classification
H3H 12D 13D 13F 14A 14D 14E 14X 1A 1F 1G 23F 2A 3C 3D 3G 6A 6B 6D 6E 6F 7B 7F AD E
U1S 2166 2171 2181 2186 H3H

(56) Documents cited
None

(58) Field of search
H3H
G4W

(54) Electronic measurement systems

(57) An electronic interface system for coupling a plurality of remote differential analogue sensors to a microcomputer, includes a central, host analogue/digital converter (ADC) unit adapted to be connected directly to the microcomputer, and a plurality (Figure 2 shows one) of remote signal conditioning modules (SCMs), each of which is associated with a plurality of individual differential analogue sensors and is connected to the central ADC unit by a four-wire cable containing power and signal leads. Each SCM includes an input multiplexer (36) for enabling sequential selection of the input signals of the plurality of sensors associated with that unit to the signal output of the latter unit. The ADC unit includes a pulse position modulator for modulating the power supply transmitted to the remote SCMs to provide control signals recoverable at the latter modules by respective ppm demodulators (28) for enabling selected sensor signals to be transmitted sequentially to the ADC.



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The drawing(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy.

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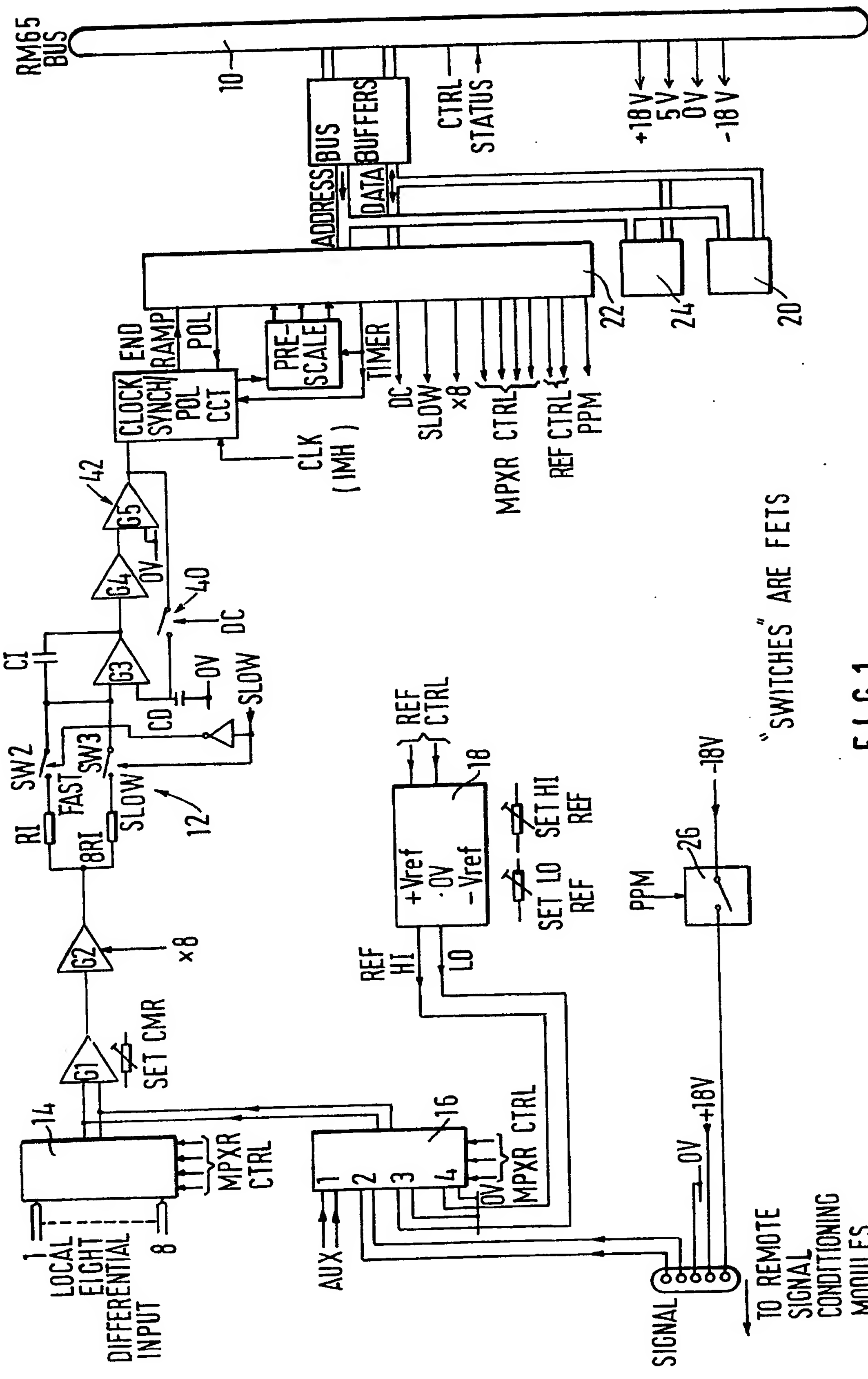
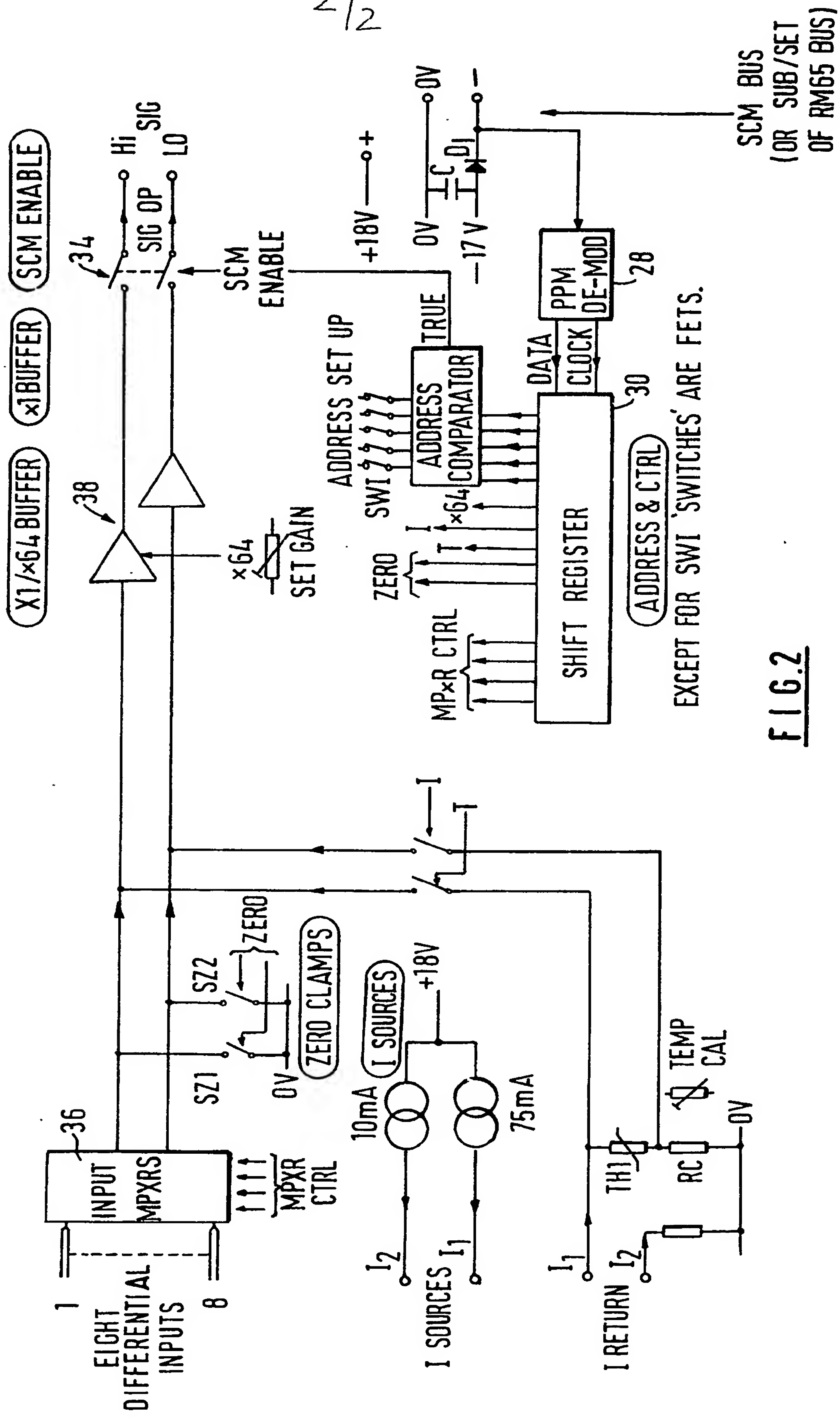


FIG.1


X1/×64 BUFFER
×1BUFFER
SCM ENABLE
38
34
Hi
SIG
LO
SIG OP
SCM
ENABLE
+18V
+
0V
0V
−17 V
−
C
D1
SCM BUS
(OR SUB/SET
OF RM65 BUS)
PPM
DE-MOD
28
DATA
CLOCK
30
ADDRESS SET UP
SW1
ADDRESS
COMPARATOR
TRUE
×64
SET GAIN
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SHIFT REGISTER
ADDRESS & CTRL
EXCEPT FOR SW1 'SWITCHES' ARE FETS.
I
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INPUT
MPXRS
MPXR
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SZ2
ZERO
0V
ZERO CLAMPS
I SOURCES
+18V
10mA
75mA
TEMP
CAL
TH1
RC
0V
1
8
EIGHT
DIFFERENTIAL
INPUTS
I2
I1
I SOURCES
I1
I2
I RETURN

FIG.2

SPECIFICATION

Improvements in and relating to electronic measurement systems

The present invention relates to electronic measurement systems of the type wherein electrical signals obtained from multiple analogue sensors have to be processed prior to being supplied to a central computer, or microcomputer where they can then be stored and manipulated as required. In particular, the present invention is concerned with the collecting and processing of such analogue input data prior to its entry into the central computer or microcomputer.

One of the major practical problems associated with the application of computers and microcomputers to "real world" applications lies in providing accurate sensor interface between the computer or microcomputer and analogue sensors, such as thermocouples and strain gauges, and in writing the software drivers.

Interface systems already exist for the processing of such analogue data but all are characterised by being complex and expensive. The present system has as its principal objective to provide the interconnection between existing powerful bus orientated microcomputers and real world analogue signals obtained from a multitude of analogue sensors, as might be found in a wide variety of different practical applications such as, for example, Process Control, Factory Automation, Energy Management, Remote Monitoring, Data Aquisition and Distributed Control Systems. The system is to be characterised by its low cost, its accuracy and its simple convenient compatibility with existing microcomputer systems.

In accordance with the present invention there is provided an electronic interface system for coupling a plurality of remote differential analogue sensors to a microcomputer, the system comprising a central, host analogue/digital converter (ADC) unit adapted to be connected directly to the mirocomputer, and a plurality of remote signal conditioning modules (SCMs), each of which is adapted to be associated with a plurality of individual differential analogue sensors and to be connected to the central ADC unit by a cable containing power and signal leads, each SCM including an input multiplexer for enabling sequential selection of the input signals of the plurality of sensors associated with that unit to the signal output of the latter unit, and the ADC unit including a means for modulating the power supply transmitted to the remote SCMs to provide control signals recoverable at the latter modules for enabling selected sensor signals to be transmitted sequentially to the ADC.

Preferably, said means in the ADC unit is adapted to use pulse position modulation (PPM) on one of the supply lines to the SCMs for transmitting the control signals thereto. Each SCM then contains a respective PPM demodulator for recovering the control signals from the power supply to that module.

In a preferred embodiment, the cable connecting each SCM to the central ADC includes only 4 wires.

Advantageously, the central ADC unit incorporates an integrator of the dual ramp type for effecting the analogue/digital conversion. The intergrator may also have a dual slope facility (fast/slow) providing different degrees of resolution.

The ADC unit further includes a main multiplexer connected to the outputs of all of the remote SCMs for sequentially transmitting selected sensor outputs to the integrator. The main multiplexer is also able to select a reference signal(s) and to pass this to the integrator after each measurement cycle for drift correction purposes.

The invention is described further hereinafter, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a block circuit diagram of one embodiment of an analogue/digital converter forming a part of an interface system in accordance with the present invention; and

Figure 2 is a block circuit diagram of one embodiment of a signal conditioning unit forming a second part of an interface system in accordance with the invention.

The particular system illustrated in the drawings is intended to interface directly with a Rockwell RM 65 card cage or with the expansion ports of the Rockwell AIM 65 and AIM 65/40 microcomputers. However, the system is by no means limited to operation with such microcomputers and the reference to same is intended solely by way of illustration.

The RM 65 bus is shown at 10 at the right hand side of Figure 1 and indicates the connection of the present system to the host microcomputer. The RM 65 bus does not, however, itself constitute part of the present apparatus.

The analogue/digital converter of Figure 1 includes an integrator which has dual ramp operation and which is indicated generally by the reference numeral 12. The integrator 12 can receive input signals from a local channel multiplexer 14 connected to a plurality (eight in this instance) of local sensors and/or a main multiplexer 16 connected to one or more remote signal conditioning modules and to a reference generator 18. The operation of the analogue/digital converter is controlled by firmware located in an EPROM 20, the control being implemented by a 6522 "VIA" element 22. Intermediate measurements required for zero correction, calibration correction or conversion to engineering units are stored in a RAM 24, as are user-defined scan control parameters. The RAM 24 may also be used as a results buffer.

A power line modulator 26 is provided which is able to interrupt the negative - 18 volt supply line to the remote signal conditioning units. This is achieved with pulse position modulation (PPM) as controlled by the VIA 22 under the command of the EPROM 20 and scan control parameters stored in the RAM 24. The signal conditioning modules are arranged to act upon these PPM commands as described below.

With reference now to Figure 2, each signal conditioning module (SCM) comprises an FET demodulator 28 for deriving clock and data signals

contained in the PPM negative supply line. The modulation is isolated from the other consuming ICs and components by the action of a diode D_1 and capacitor C_1. The clock and data signals recovered in the demodulator 28 are fed into a shift register 30, some of whose outputs feed the various FET switches and some an Address comparator 32. At the Address comparator 32 the shift register contents are compared with a pre-set 5 bit address code which has been set up by the user on a DIL switch SW1. In the event of a match, i.e. that particular signal conditioning module is being addressed, two SCM enable switches 34 are closed, so connecting analogue outputs from an input multiplexer 36 to the analogue bus. The input multiplexer 36 can receive differential inputs from (in this case) eight analogue sensors (not shown) disposed in the vicinity of that module. The outputs from the multiplexer 36 can be amplified as necessary and bufferred at 38.

The signal leads from the sensors are clamped in screw terminal blocks in an isothermal assembly (not shown) whose temperature is monitored precisely by a precision thermistor TH1. The use of the isothermal block construction ensures accurate cold junction compensation on each module for direct thermocouple measurements.

The operation of a measurement cycle is as follows.

When quiescent, the ADC is in a Drift Correct (DC) mode in which a reference signal from the reference source 18 is commanded to give 0v output and the multiplexers 14, 16 are set to block input signals and feed the 0v reference through to the integrator 12. To give the fastest drift correct action, the integrator is set to FAST. A drift correct switch 40 is closed. A drift correct capacitor CD quickly assumes a voltage which is the sum of all of the offsets in the chain, V12 the reference, multiplexer, G1, G2 and G3.

When commanded to measure an input, the appropriate conditions are set up at the selected signal conditioning module by way of the PPM modulated negative line, and the correct gain is selected at an amplifier G2. When addressed, the relevant signal conditioning module acquires the analogue bus and transmits its signals to the ADC. After a delay to allow settling, the integrator input switches SW2 (FAST) and SW3 (SLOW) are opened, the main multiplexer 16 selects the analogue bus and then the appropriate integrator input switch SW2, SW3 closes causing the integrator to commence "ramp up" (RU) on the presented signal. After a 20ms (slow) or 1.25ms (fast) ramp up time the integrator input switch opens and the reference size and reference polarity is commanded (the low reference if on X8 gain, the high reference if on X1 gain, and polarity such as to return the integrator to zero). Following a settling delay, the integrator input switch closes again to commence "ramp down" and the elapsed time at which the ram crosses the zero at a comparator 42 gives a measure of the original input. The system then returns to drift correct and the cycle repeats as necessary.

Measurement cycles are used not only to measure the inputs presented to the remote signal conditioning unit(s), but also to determine the zero offsets and current calibration factors of the selected multiplexer so that these input readings may be suitably zero corrected and scaled.

It will be noted that the whole of the ADC analogue chain, except for the high integrity multiplexer, but including the reference, is zero corrected. Moreover the only calibration error that can exist at the ADC is that due to the reference alone; all other sources cancel out since the error is common to ramp up and ramp down.

For zero correction measurements, switches SZ1 and SZ2 (Figure 2) are closed, so enabling the rmoval of all offsets except the 1 or 2 μv in the input multiplexers. Zero correction measurements are standard measurements whose results are stored digitally for later manipulation.

The zero switches are also used to allow single ended measurements of thermistor TH1 and a calibration resistor RC for ambient temperature and current source measurement. The latter is necessary to allow accurate temperature measurements using PRTs.

The use of the dual ramp technique in the A-D conversion has a number of advantages for data aquisition, viz;

(i) good noise immunity since it is an integrating technique;

(ii) ability to select next inputs during ramp down on previous input, so allowing generous condition settling time; and

(iii) good LF noise performance because of analogue drift correction.

One of the main features of the present system is its ability for remote operation. "Real world" sensors are inclined to be distributed in small clusters as opposed to being all located at a central locality. The result of this distribution problem has previously led to a major expense in cable cost (sometimes more than the measuring equipment) and a significant loss in signal integrity. The present system eliminates these problems in that the signal conditioning units may be used up to 100 metres from the host ADC without any significant degradation of signal. Connection can be by means of four wires only. No external power requirements are necessary for the remote modules. The remote units can be corrected in parallel or be daisy chained together over the defined distance. In the described example, each remote module provides 8 channels of differential input and one host ADC can support 32 modules, providing a total of 256 analogue inputs.

In a perferred embodiment of the described example, analogue to digital conversion is implemented by a 16 bit dual slope converter capable of operating at 16 readings/second or 160 readings/second at reduced resolution. At 16 samples/second this technique offers high noise rejection, particularly at line frequences and line harmonics.

Comprehensive firmware on the board permits simple operation by means of a natural extension to the AIM65 BASIC interpreter. All hardware-dependent aspects of the operation are controlled by this firmware. The on-board buffer memory can accept up to 256 results which can be accessed directly in machine code, and FORTH.

The automatic range selection facility eliminates the tedium of initial setup and sensor linearisation ensures that readings are presented in the engineering units required.

CLAIMS

1. An electronic interface system for coupling a plurality of remote differential analogue sensors to a microcomputer, the system comprising a central, host analogue/digital converter (ADC) unit adapted to be connected directly to the microcomputer, and a plurality of remote signal conditioning modules (SCMs), each of which is adapted to be associated with a plurality of individual differential analogue sensors and to be connected to the central ADC unit by a cable containing power and signal leads, each SCM including an input multiplexer for enabling sequential selection of the input signals of the plurality of sensors associated with that unit to the signal output of the latter unit, and the ADC unit including a means for modulating the power supply transmitted to the remote SCMs to provide control signals recoverable at the latter modules for enabling selected sensor signals to be transmitted sequentially to the ADC.

2. An electronic interface system as claimed in claim 1, wherein said means in the ADC unit is adapted to use pulse position modulation (PPM) on one of the supply lines to the SCMs for transmitting the control signals thereto.

3. An electronic interface system as claimed in claim 2, wherein each SCM contains a respective PPM demodulator for recovering the control signals from the power supply to that module.

4. An electronic interface system as claimed in claim 1, 2 or 3 wherein each SCM is connected to the central ADC by a respectibe cable which comprises four wires only.

5. An electronic interface system as claimed in any of claims 1 to 4, wherein the central ADC unit incorporates an integrator of dual ramp facility for effecting the analogue/digital conversion.

6. An electronic interface system as claimed in claim 5 wherein said integrator also has a dual slope facility (fast/slow) providing different degrees of resolution.

7. An electronic interface system as claimed in any of claims 1 to 6, wherein the ADC unit further includes a main multiplexer connected to the outputs of all of the remote SCMs for sequentially transmitting selected sensor outputs to the integrator.

8. An electronic interface system as claimed in claim 7 wherein the main multiplexer is adapted to select a reference signal(s) and to pass this to the integrator after each measurement cycle for drift correction purposes.

9. An electronic interface system substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

Printed in the UK for HMSO, D8818935, 7/84, 7102.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.